National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

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Disaster Risk Reduction Across the Americas Discussion Sessions: NASA Remote Sensing for Monitoring Hydrometeorological Disasters

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Week 2

Outline

- Remote Sensing and Modeling Data Available for Hydrometeorological Disasters
- Flood and Storm Monitoring Using Remote Sensing and Reanalysis Modeling Data

Remote Sensing and Modeling Data Available for Hydrometeorological Disasters

Relevant Remote Sensing and Model Data

Precipitation	Monitor development and propagation of precipitation systems and intensity to assess potential for flooding
Land Cover	Detection of inundation on previously dry surfaces
Terrain	Determine water flow direction and low lying, flood-prone areas
Soil Moisture	Influence on water infiltration, runoff, and streamflow
Winds	Monitor and assess storm intensity and spatial extent
Sea Level Pressure	Monitor and assess storm intensity and track

Flood Monitoring Data Sources

Quantity	Satellite	Sensor
Precipitation	• GPM (Global Precipitation Measurement) • TRMM (Tropical Rainfall Measurement Mission)	• GPM Microwave Imager (GMI), Dual-Frequency Precipitation Radar (DPR) • TRMM Microwave Imager (TMI), Precipitation Radar (PR), Visible and Infrared Scanner (VIRS)
Land Cover	• Landsat • Terra • Aqua • SNPP (Suomi National Polar Partnership) • Sentinel-1A	• Enhanced Thematic Mapper (ETM+), Operational Land Imager (OLI) • MODerate Resolution Imaging Spectroradiometer (MODIS) • Visible Infrared Imaging Suite (VIIRS) • C-Band Synthetic Aperture Radar (SAR)
Terrain	Shuttle Radar Topography Mission (SRTM)	C-Band Radar
Soil Moisture	SMAP (Soil Moisture Active Passive)	Microwave Band Radar

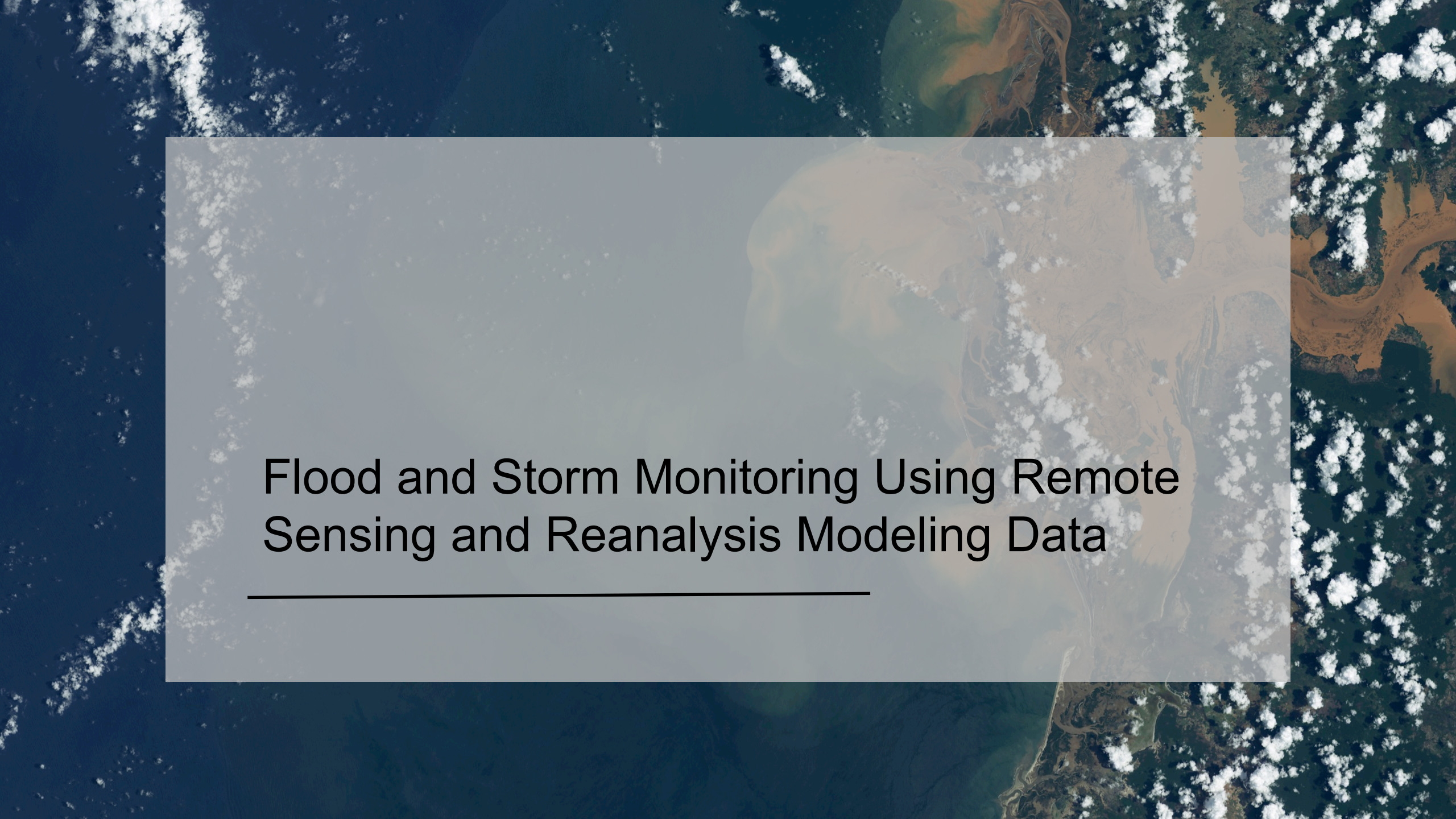
Flood Monitoring Data Sources

Quantity	Satellite	Temporal Coverage; Resolution	Spatial Coverage; Resolution
Precipitation	• GPM (IMERG) • TRMM (TMPA)	• 02/2014 – Present; 30 min • 11/1997 - 04/2015; 3 hrs	• Global, 60°S - 60°N; 0.1° x 0.1° • Global, 50°S - 50°N; 0.25° x 0.25°
Land Cover	• Landsat • Terra • Aqua • SNPP • Sentinel-1A	• 07/1972 – Present; 16 days • 12/1999 – Present; Daily • 05/2002 – Present; Daily • 10/20111 – Present; Daily • 04/2014 – Present; 12 days	• Global; 30 m • Global; 250 m – 1 km • Global; 250 m – 1 km • Global; 375 m – 750 m • Global; 5 m x 20 m
Terrain	SRTM	• February 2000; Static	• Global; 30 m, 90 m
Soil Moisture	SMAP	• 01/2015 – Present; 3 days	• Global: 36 km

Storm Monitoring Data Sources

Quantity	Model	Temporal Coverage; Resolution	Spatial Coverage; Resolution
Winds and Sea Level Pressure	• Modern Era Retrospective-Analysis for Research and Application (MERRA)	• 1979 – Present; Hour, Month	• Global; 0.5° x 0.625°

For more information about satellites, sensors, and models see Sessions 1, 2A, and 2B on the Fundamentals of Remote Sensing: https://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing



Flood and Storm Monitoring Using Remote Sensing and Reanalysis Modeling Data

Flood Monitoring Tools

- Flooding Tools Based on Precipitation Observations
  - Global Flood Monitoring System (GFMS)
  - Extreme Rainfall Detection System-2 (ERDS2)
- Flooding Tools Based on Land Cover Observations
  - MODIS Near Real-Time (NRT) Flood Mapping
  - Dartmouth Flood Observatory (DFO, DFO River Watch)
  - Global Flood Detection System 2 (GFDS2)
- Global Disasters Alert and Coordination System (GDACS)

GFMS, ERDS2 (before and during flooding events)

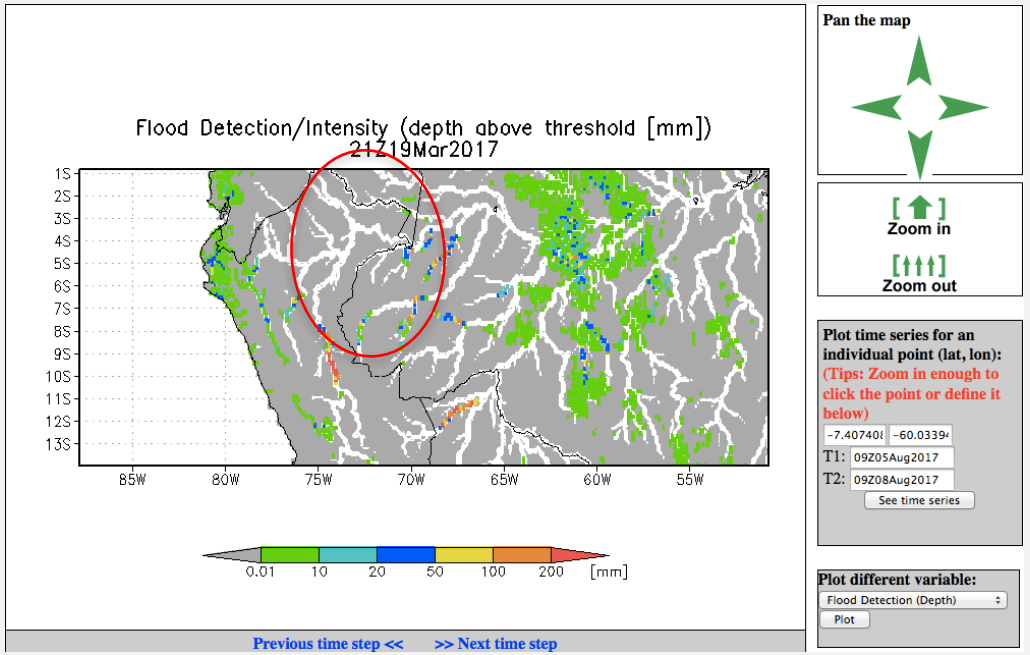
MODIS-NRT, DFO, GDACS (during and after flooding events)

Global Flood Monitoring System (GFMS)

http://flood.umd.edu/

- Based on TMPA, provides global maps, time series, and animations (50°S-50°N) of:
  - instantaneous rain rate every 3 hrs
  - accumulated rain over 24, 72, and 168 hrs
  - streamflow rates and flood intensity at 1/8th degree (~12 km) and 1 km
  - Near real-time and archives since 2013

Interactive Features



Flooding in Peru, 19 March 2017

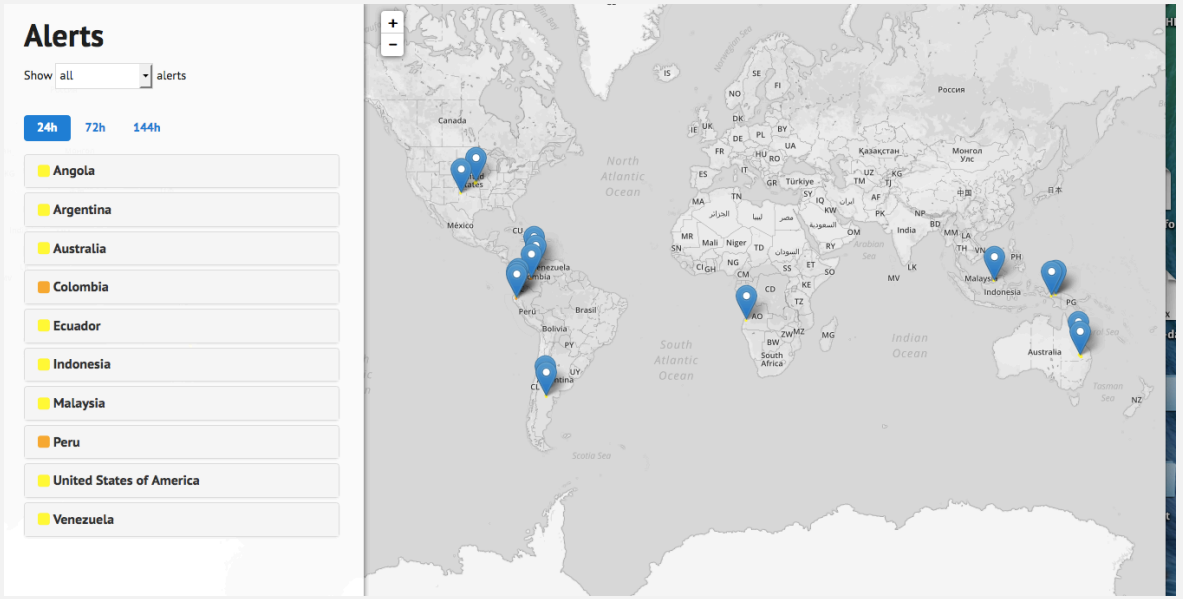
Note: TRMM is no longer flying, but TRMM-based calibration is used to provide near real-time rainfall from a constellation of national & international satellites for flooding applications. Near real-time IMERG data are available from: ftp://jsimpson.pps.eosdis.nasa.gov

Extreme Rainfall Detection System-2 (ERDS2)

http://erds.ithacaweb.org/

- Uses near real-time TRMM-TMPA and NOAA-Global Forecasting System (GFS) rainfall for monitoring and forecasting accumulated rainfall
- The TMPA historical archive is used as reference data to calculate extreme rainfall thresholds
- The combination of TMPA rainfall amount, GFS forecasted rainfall information, and the reference data, generates flooding information

- ERDS is one of the tools used by the UN World Food Programme (WFP) Emergency Preparedness Unit

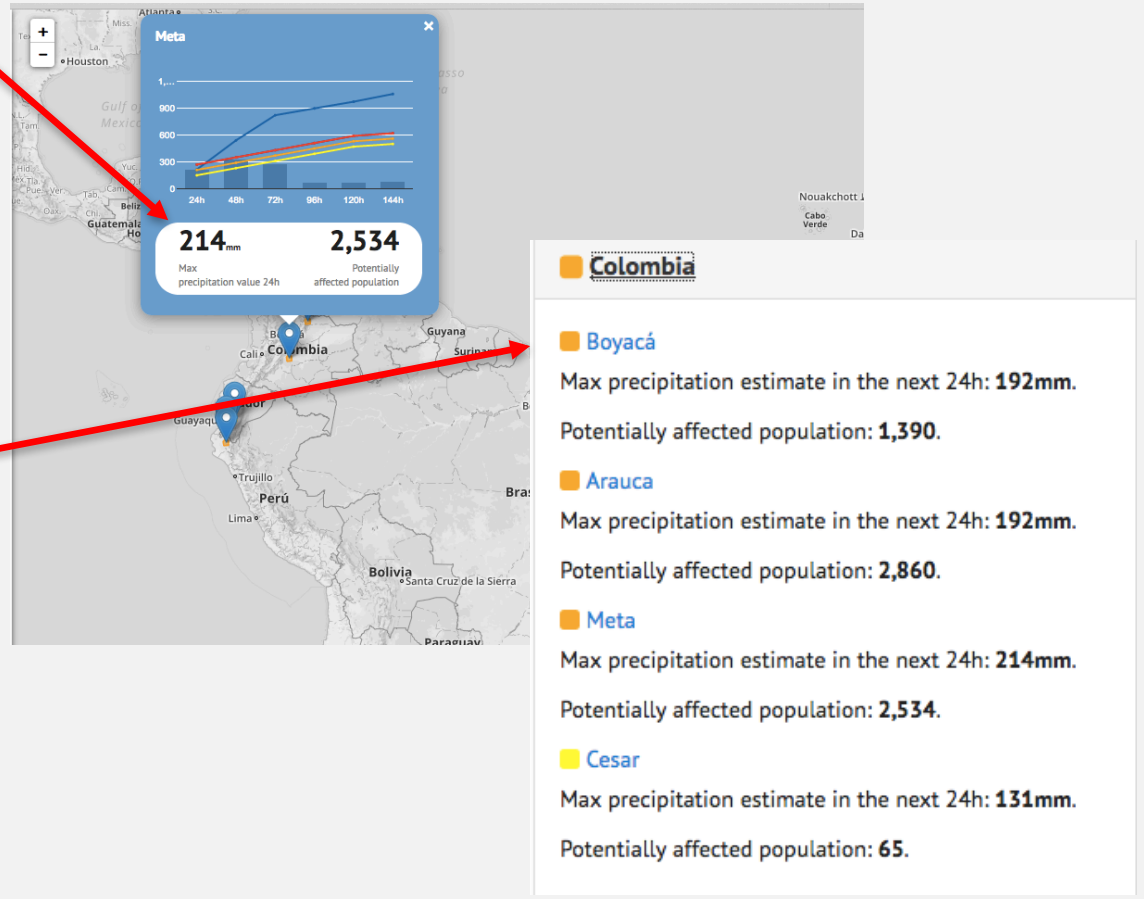


Extreme Rainfall Detection System-2 (ERDS2)

http://erds.ithacaweb.org/

- Global maps and time series of near real-time (50°S-50°N) and forecasted accumulated rainfall
  – 24, 48, 72, 96, 120, and 144 hours
- Extreme rainfall alerts at 0.25°x0.25° levels and administrative district levels
- Event-specific information
  – list of affected countries
  – an estimation of affected population

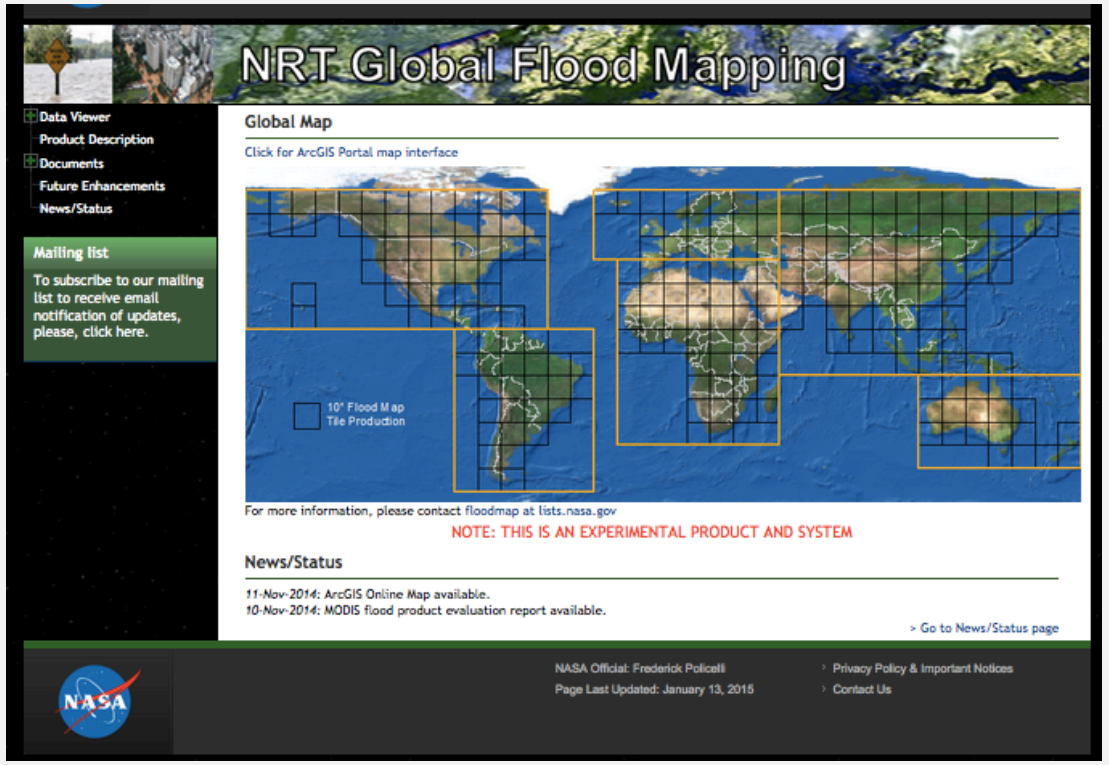
Value-Added Flood Information



MODIS NRT Global Flood Mapping

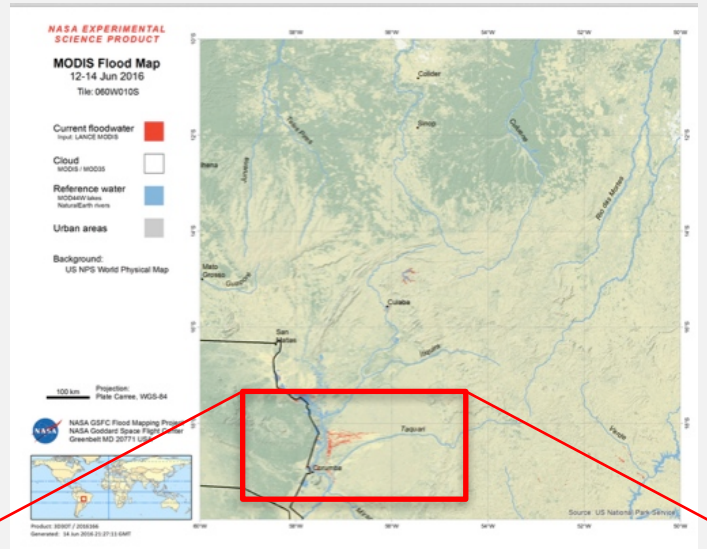
https://floodmap.modaps.eosdis.nasa.gov/

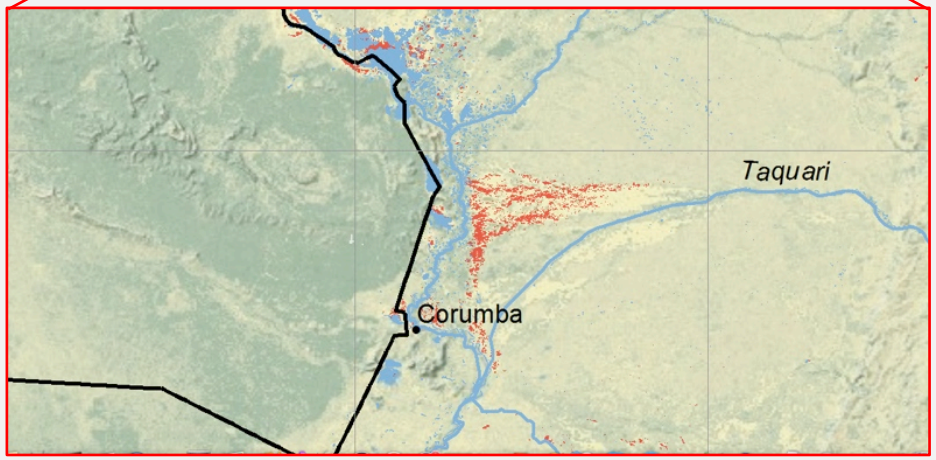
- Based on MODIS reflectance at 250 m resolution composited on 2, 3, and 14 days
- Flood maps available on 10°x10° tile
- Permanent and surface flood water data available
- Cloud or terrain shadows can be misinterpreted as surface water
- Provides near real-time flood mapping since Jan 2013



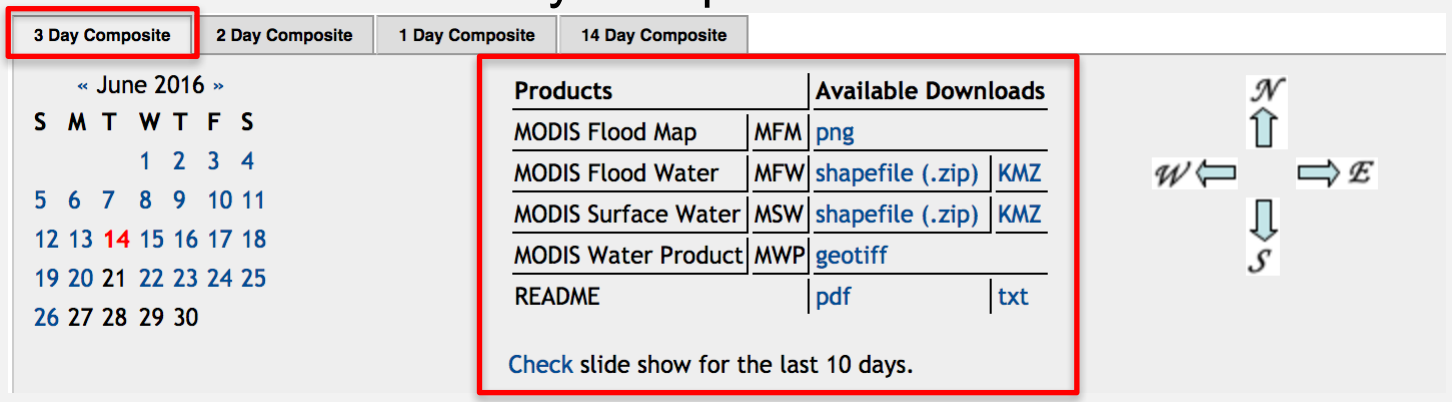
MODIS Flood Mapping: Southern Brazil, June 12-14, 2016

https://floodmap.modaps.eosdis.nasa.gov/





3-Day Composites



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yyyydoy (year, day of year)

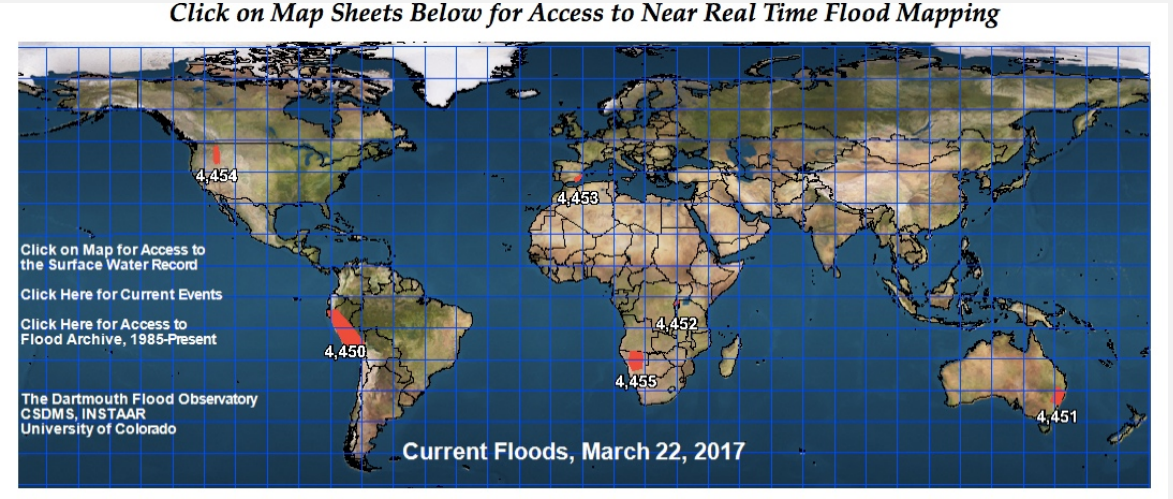
lon-lat

2 or 3 day observations

Dartmouth Flood Observatory (DFO)

http://floodobservatory.colorado.edu/

- Uses flood mapping based on MODIS reflectance
  – same as MODIS NRT
- Also uses Landsat 8, EO-1, and ASTER images
  – uses COSMO-SkyMed and Sentinel-1 synthetic aperture radar (SAR) when available)
- Current flood events are analyzed with multiple data sources (next two slides), including media report

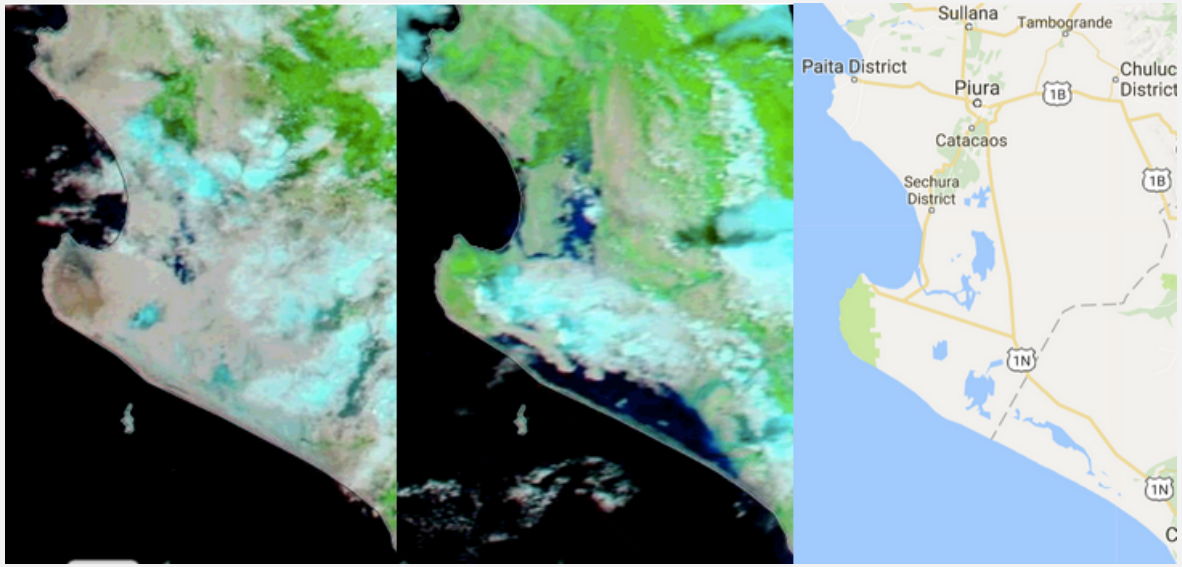


- Provides near real-time, current, and past flood event mapping
- Red areas (above) indicate inundated surface

DFO Flood Event: Peru

http://floodobservatory.colorado.edu/

Coastal flooding during local El Nino conditions (middle, Mar 27, 2017), compared to previous year (left image, Mar 27, 2016). Source: MODIS



Flooding (red) from comparing Mar 20, 2017 and Jan 19, 2017.
Source: Copernicus data (2017)/ESA

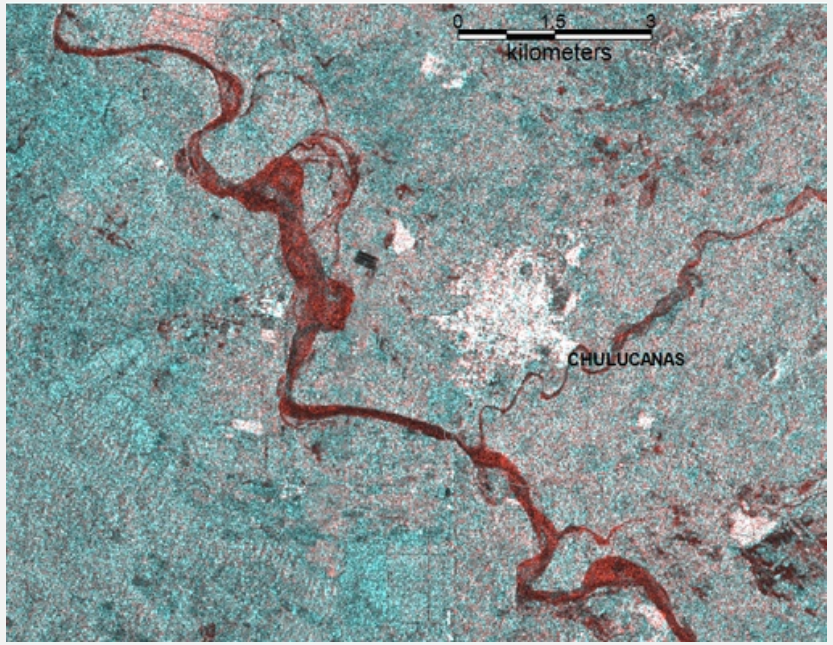
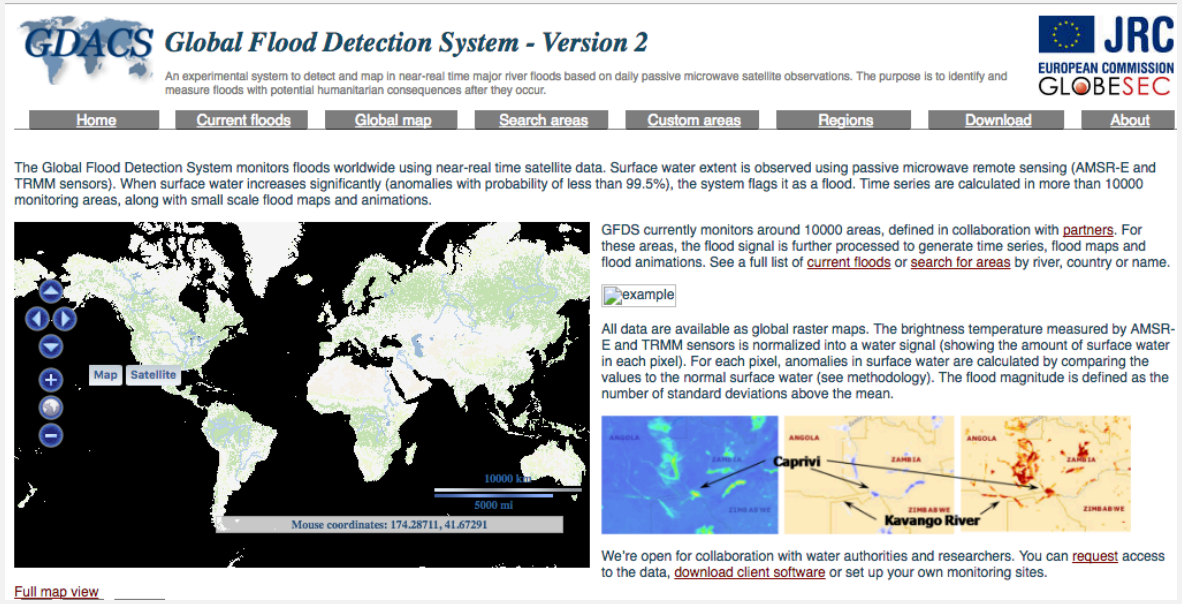


Image Sources: DFO

Global Flood Detection System 2 (GFDS2)

http://www.gdacs.org/flooddetection/

GFDS2 flooding information is used by GDACS



Developed for GDACS in collaboration with DFO

Interactive current flood map and flood list

Global Disasters Alert and Coordination System(GDACS)

http://www.gdacs.org/

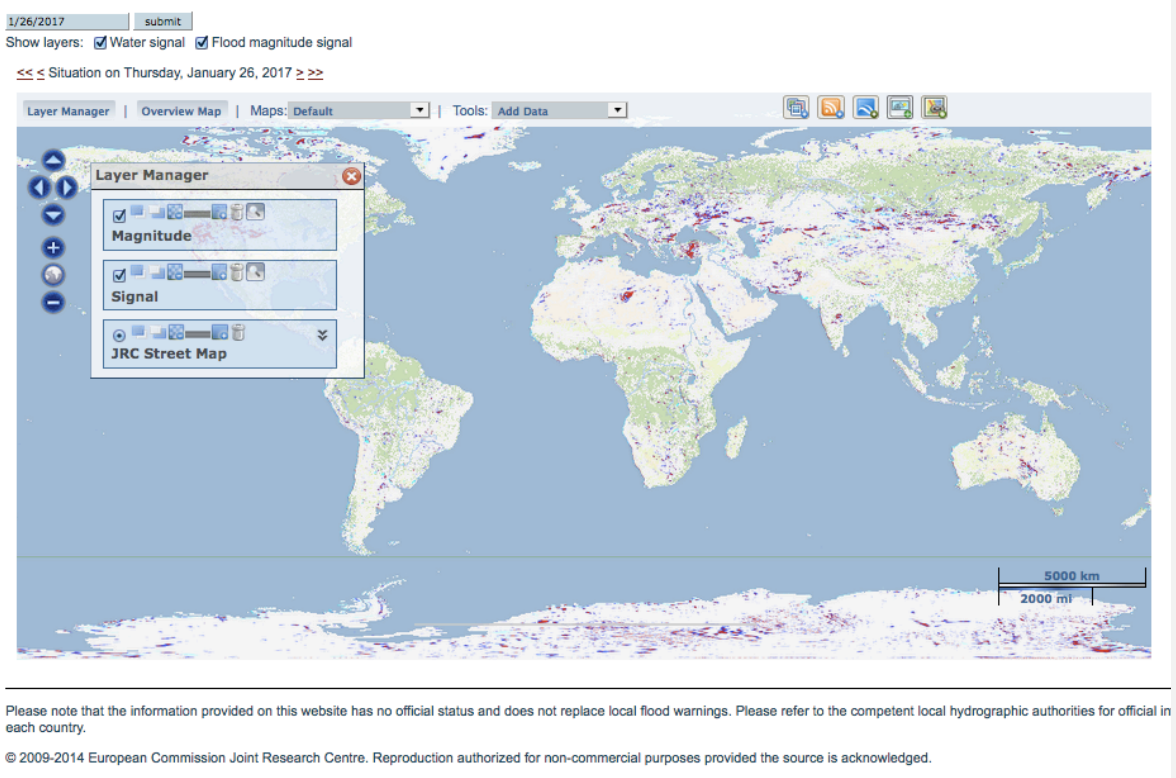
- **Floods**
  - inundation
  - deaths
  - displacement
- **Tropical Cyclones**
  - winds
  - heavy rains
  - storm surge
- **Earthquakes and Tsunamis**
  - intensity and magnitude
  - hypocenter depth
  - population within 100 km of epicenter
  - vulnerability of affected countries

Various models and data are used to obtain this information: http://portal.gdacs.org/Models

GDACS Approach for Disaster Alerts: Floods

http://portal.gdacs.org/Models/

Issues flood alerts and maps using satellite-based information from the GFDS2 and population data

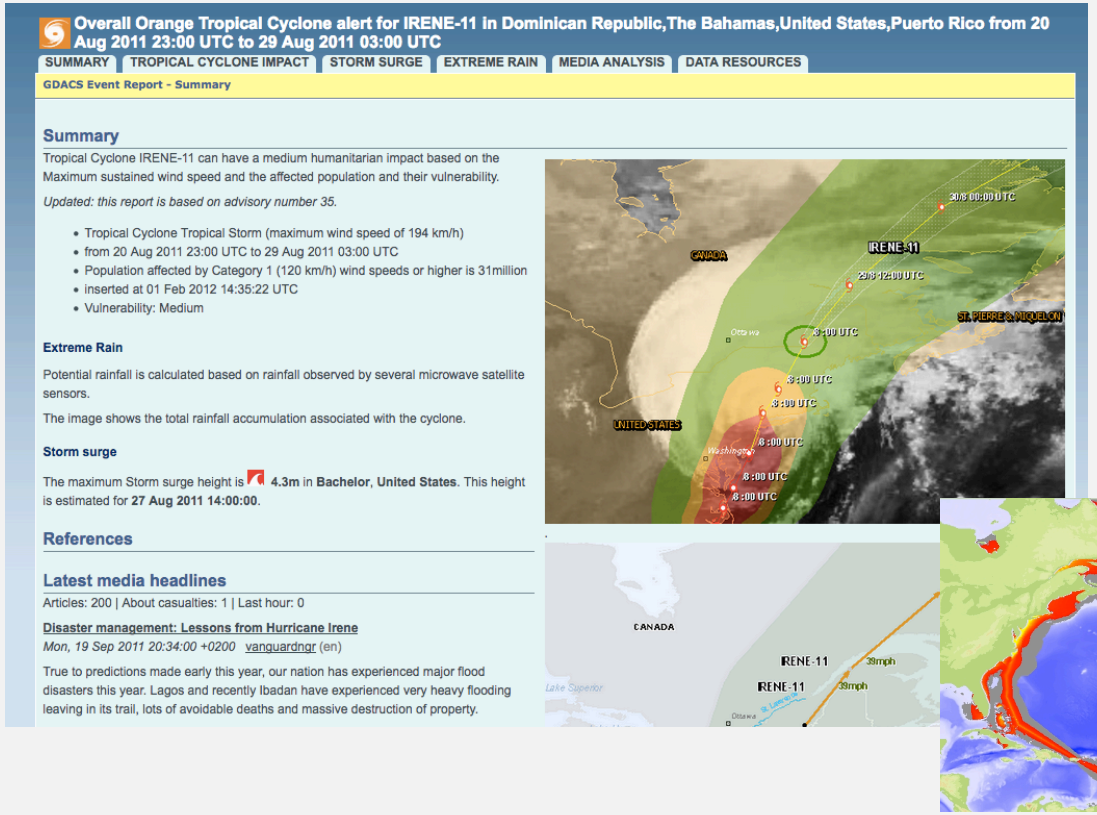


- Red Alert
  - more than 1,000 dead or 800,000 displaced
- Orange Alert
  - more than 100 dead or 80,000 displaced
- Green Alert
  - All other floods

Image Credit: GFDS Version 2 http://www.gdacs.org/flooddetection/global_map.aspx

Hurricane Irene Information in GDACS

http://www.gdacs.org/report.aspx?eventid=25532&episodeid=35&eventtype=TC

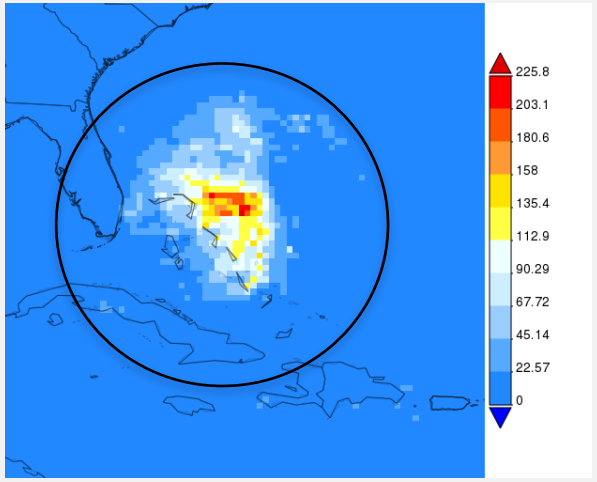


- Storm Intensity and Alert
- Storm Track, Extent
- Multiple Data Sources
- Storm Surge
- Media reports

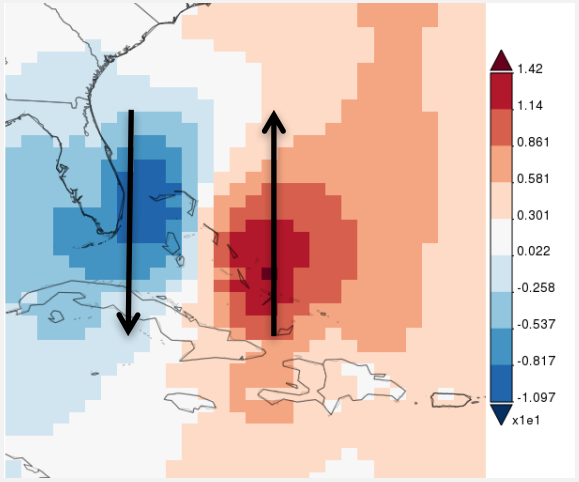
Hurricane Irene from TRMM and MERRA

August 25, 2011

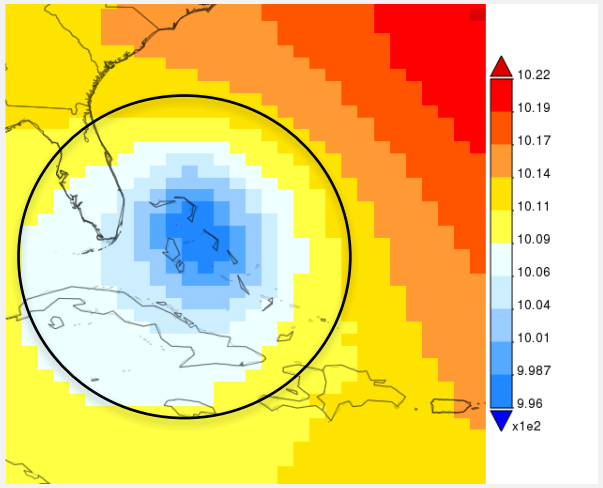
TMPA Rain (mm/day)



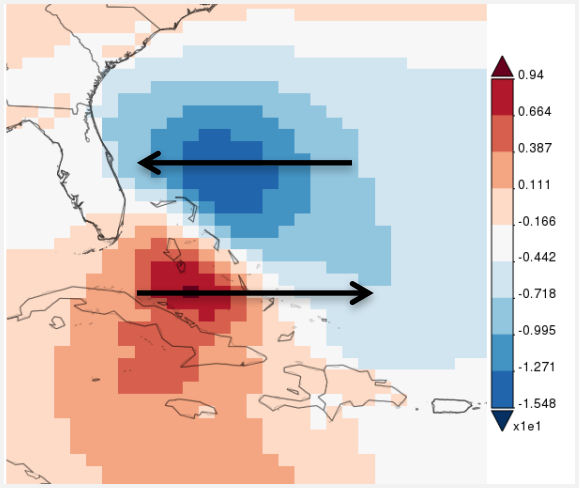
MERRA North-South Wind (m/s)



MERRA Sea Level Pressure (hPa)



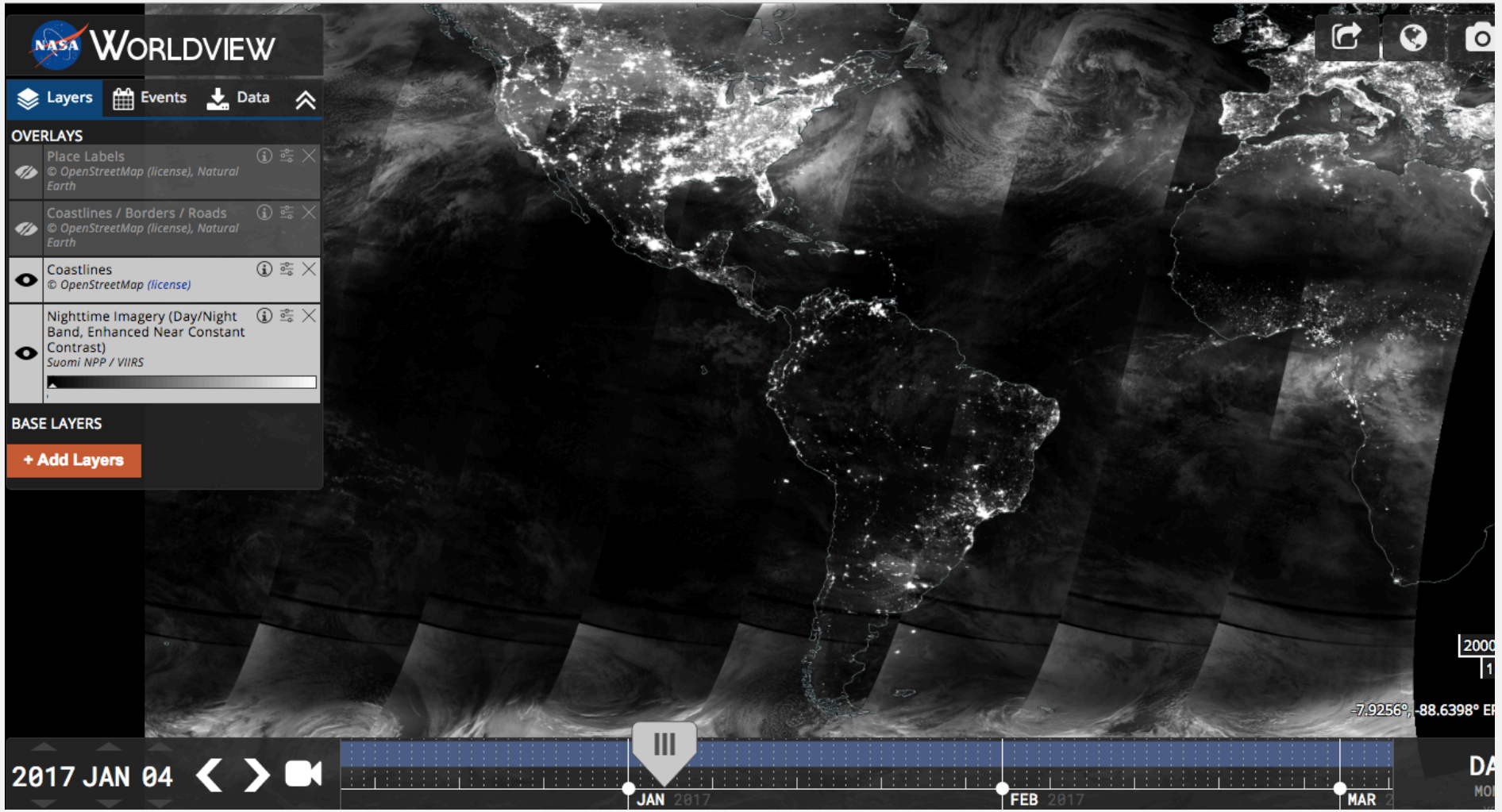
MERRA East-West Wind (m/s)



- Track storms with MERRA hourly data
- Monitor precipitation with GPM (after 2014) with half-hourly data
- Web tools to animate storm to monitor track and extent

Monitor Disaster-related Power Outage by Using VIIRS Night Imagery

http://go.nasa.gov/2iFEzX8



For More Details

- NASA Remote Sensing for Flood Monitoring and Management:
  - https://arset.gsfc.nasa.gov/disasters/workshops/flood-17
- Overview of the Global Disaster Alert and Coordination System (GDACS):
  - https://arset.gsfc.nasa.gov/disasters/webinars/GDACS17


Thank You

Summary of Flooding Web Tools Based on Precipitation

Flood Tool, Satellite, Instrument, or Model	Quantities Used as Inputs	Hydrological Model	Output	Spatial Coverage and Temporal Resolution
GFMS • TRMM/ TMPA-RT • MERRA	• Rain rate • Surface temperature • Winds	• VIC-UMD DRTR	• Flood intensity • Streamflow • Accumulated rainfall	• 50°S-50°N • 12 km and 1 km • Jan 2001 – NRT 3 hr updates
ERDS • TRMM/ TMPA-RT • GFS	• Rain rate		• NRT & Forecast flood alerts • Accumulated rainfall • Population affected	• 50°S-50°N • 0.25°x0.25° • NRT and up to 72 hr forecast, 3 hr updates

Summary of Flooding Web Tools Based on Land Surface Observations

Flood Tool, Satellite, Instrument, or Model	Quantities Used as Inputs	Output	Spatial Coverage and Temporal Resolution
MODIS-NRT • Terra/Aqua MODIS	• Reflectance Bands 1, 2, 7	• Inundation map • Flood water • Surface water	• Global 250 m • NRT 2, 3, and 14 day composites • 2013-present
DFO • Terra/Aqua MODIS	• Reflectance Bands 1, 2, 7	• MODIS Inundation map • Images when available: SAR EO-1 Landsat	• Global 250 m • 14 day composite • Flood catalog (since 1985)
GFDS2 & DFO River Watch • Aqua/AMSR-E,TRMM/TMI, GCOM-W/AMSR2, GPM/GMI	• Microwave Brightness Temperature (37 GHz) • Water Balance Model • River Gauge Discharge	• Flood Magnitude • River discharge time series at selected locations	• Global, NRT • Past flood since 2003